APPENDIX

G Slurry Displacement Piles

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SECTION 1
MUD WEIGHT (DENSITY)

1.1 Description. This test procedure is a method for determining the weight of a given volume of liquid. Mud weight may be expressed as pounds per gallon (lb/gal), pounds per cubic foot (lb/ft^3), grams per cubic centimeter (g/cm^3), or kilograms per cubic meter (kg/m^3).

1.2 Equipment

a. Any instrument of sufficient accuracy to permit measurement within ±0.1 lb/gal (or 0.5 lb/ft^3, 0.01 g/cm^3, 10 kg/m^3) may be used. The mud balance (Fig. 1.1 and 1.2) is the instrument generally used for mud weight determinations. The mud balance is designed such that the mud cup, at one end of the beam, is balanced by a fixed counterweight at the other end, with a sliding-weight rider free to move along a graduated scale. A level-bubble is mounted on the beam to allow for accurate balancing. (Attachments for extending the range of the balance may be used when necessary).

b. Thermometer: 32-220°F (0-105°C)

1.3 Procedure

a. The instrument base should be set on a flat, level surface.

b. Measure the temperature of the mud and record on the Drilling Mud Report form.

c. Fill the clean, dry cup with mud to be tested; put the cap on the filled mud cup and rotate the cap until it is firmly seated. Insure that some of the mud is expelled through the hole in the cap in order to free any trapped air or gas (see Appendix D for Air Removal).

d. Holding cap firmly on mud cup (with cap hole covered), wash or wipe the outside of the cup clean and dry.

e. Place the beam on the base support and balance it by moving the rider along the graduated scale. Balance is achieved when the bubble is under the center line.

f. Read the mud weight at edge of the rider toward the mud cup. Make appropriate corrections when a range extender is used.

1.4 Procedure-Calibration. The instrument should be calibrated frequently with fresh water. Fresh water should give a reading of 8.3 lb/gal or 62.3 lb/ft^3 (1000 kg/m^3) at 70°F (21°C). If it does not, adjust the balancing screw or the amount of lead shot in the well at the end of the graduated arm as required.

1.5 Calculation

a. Report the mud weight to the nearest 0.1 lb/gal or 0.5 lb/ft^3 (0.01 g/cm^3, 10 kg/m^3).

b. To convert the reading to other units, use the following:

$$\text{Density} = g/cm^3 = \frac{lb/ft^3}{62.3} = \frac{lb/gal}{8.345} \qquad (a)$$

$$kg/m^3 = (lb/ft^3)(16) = (lb/gal)(120) \qquad (b)$$

$$\text{Mud gradient, psi/ft} = \frac{lb/ft^3}{144},\ \frac{lb/gal}{19.24},\ \text{or}\ \frac{kg/m^3}{2309} \qquad (c)$$

TABLE 1.1
DENSITY CONVERSION

1	2	3	4
pounds per gallon (lb/gal)	pounds per cubic foot (lb/ft^3)	grams per cubic centimeter (g/cm^3)*	kilograms per cubic meter (kg/m^3)
6.5	48.6	0.78	780
7.0	52.4	0.84	840
7.5	56.1	0.90	900
8.0	59.8	0.96	960
8.3	62.3	1.00	1000
8.5	63.6	1.02	1020
9.0	67.3	1.08	1080
9.5	71.1	1.14	1140
10.0	74.8	1.20	1200
10.5	78.5	1.26	1260
11.0	82.3	1.32	1320
11.5	86.0	1.38	1380
12.0	89.8	1.44	1440
12.5	93.5	1.50	1500
13.0	97.2	1.56	1560
13.5	101.0	1.62	1620
14.0	104.7	1.68	1680
14.5	108.5	1.74	1740
15.0	112.5	1.80	1800
15.5	115.9	1.86	1860
16.0	119.7	1.92	1920
16.5	123.4	1.98	1980
17.0	127.2	2.04	2040
17.5	130.9	2.10	2100
18.0	134.6	2.16	2160
18.5	138.4	2.22	2220
19.0	142.1	2.28	2280
19.5	145.9	2.34	2340
20.0	149.6	2.40	2400
20.5	153.3	2.46	2460
21.0	157.1	2.52	2520
21.5	160.8	2.58	2580
22.0	164.6	2.64	2640
22.5	168.3	2.70	2700
23.0	172.1	2.76	2760
23.5	175.8	2.82	2820
24.0	179.5	2.88	2880

*Same as specific gravity (sg).

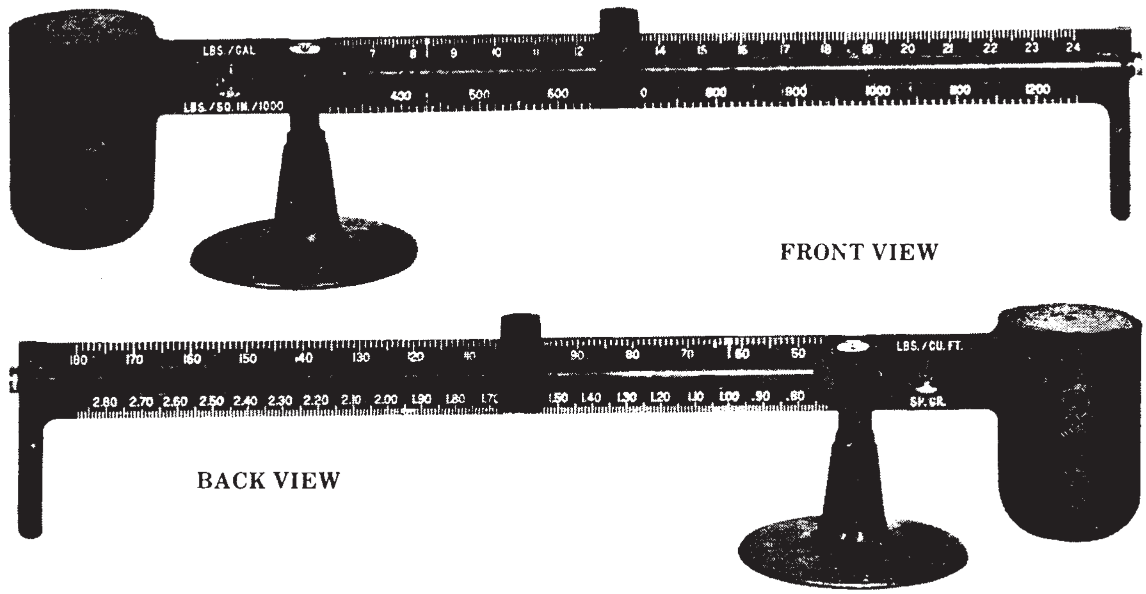

FIG. 1.1
MUD BALANCE

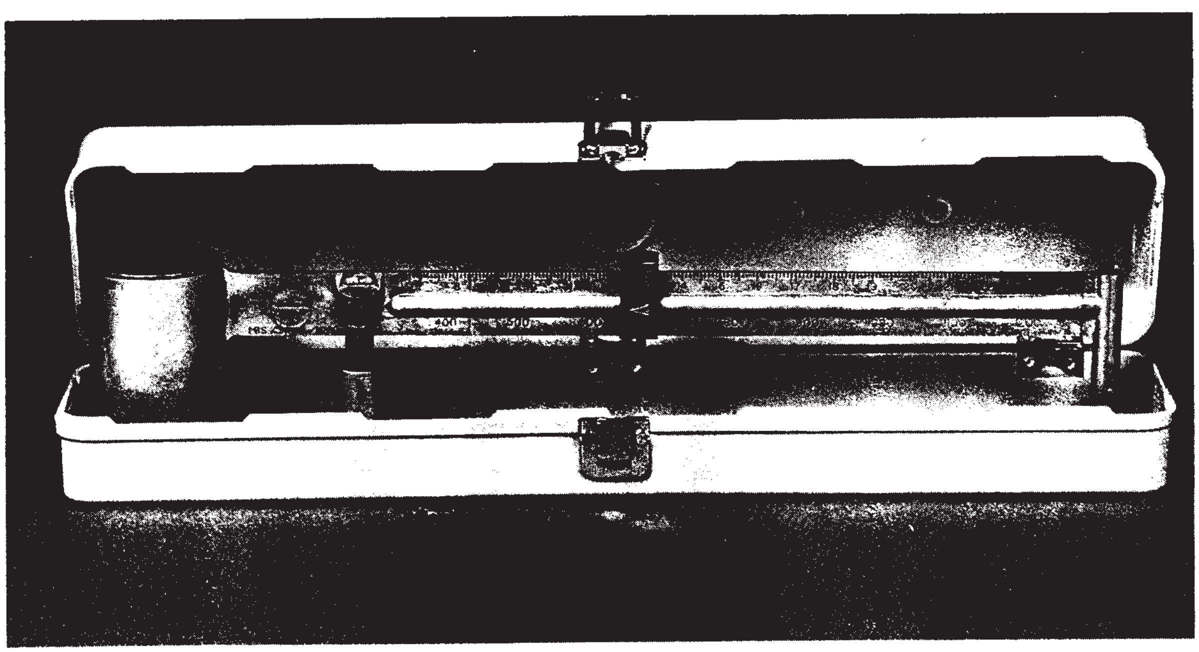

FIG. 1.2
MUD BALANCE AND CASE

SECTION 2
VISCOSITY AND GEL STRENGTH

2.1 Description

a. The following instruments are used to measure viscosity and/or gel strength of drilling fluids:

1. Marsh Funnel — a simple device for indicating viscosity on a routine basis.
2. Direct-indicating viscometer — a mechanical device for measurement of viscosity at varying shear rates.

b. Viscosity and gel strength are measurements that relate to the flow properties of muds. The study of deformation and flow of matter is rheology. An in-depth discussion of rheology is made in API Bulletin 13D: *The Rheology of Oil-Well Drilling Fluids.*

MARSH FUNNEL

2.2 Equipment

a. Marsh Funnel

A Marsh Funnel (see Fig. 2.1) is calibrated to outflow one quart (946 cm^3) of fresh water at a temperature of 70 ±5°F (21 ±3°C) in 26 ± 0.5 seconds. A graduated cup is used as a receiver.

Specifications
Funnel Cone
Length .... 12.0 in. (305 mm)
Diameter .... 6.0 in. (152 mm)
Capacity to bottom of screen .... 1500 cm^3
Orifice
Length .... 2.0 in. (50.8 mm)
Inside Diameter .... 3/16 in. (4.7 mm)
Screen .... 12 mesh
Has 1/16 in. (1.6 mm) openings and is fixed at a level ¾ in. (19.0 mm) below top of funnel.

b. Graduated cup: one-quart

c. Stopwatch

d. Thermometer: 32-220°F (0-105°C)

2.3 Procedure

a. Cover the funnel orifice with a finger and pour freshly sampled drilling fluid through the screen into the clean, upright funnel. Fill until fluid reaches the bottom of the screen.

b. Remove finger and start stopwatch. Measure the time for mud to fill to one-quart (946 cm^3) mark of the cup.

c. Measure temperature of fluid in degrees F (C).

d. Report the time to nearest second as Marsh Funnel viscosity. Report the temperature of fluid to nearest degree F (C).

FIG. 2.1
MARSH FUNNEL AND CUP

SECTION 5
SAND

5.1 Description. The sand content of mud is the volume percent of particles larger than 74 microns. It is measured by a sand-screen set (see Fig. 5.1).

5.2 Equipment

a. 200-mesh sieve, 2.5 in. (63.5 mm) in diameter

b. Funnel to fit sieve

c. Glass measuring tube marked for the volume of mud to be added. The tube is graduated from 0 to 20 percent in order to read directly the percentage of sand.

5.3 Procedure

a. Fill the glass measuring tube with mud to the "mud" mark. Add water to the next mark. Close the mouth of the tube and shake vigorously.

b. Pour the mixture onto the clean, wet screen. Discard the liquid passing through the screen. Add more water to the tube, shake, and again pour onto the screen. Repeat until the tube is clean. Wash the sand retained on the screen to free it of any remaining mud.

c. Put the funnel upside down over the top of the sieve. Slowly invert the assembly and insert the tip of the funnel into the mouth of the glass tube. Wash the sand into the tube by playing a fine spray of water through the screen. Allow the sand to settle. From the graduations on the tube, read the volume percent of the sand.

d. Report the sand content of the mud in volume percent. Report the source of the mud sample, i.e., above shaker, suction pit, etc. Coarse solids other than sand will be retained on the screen (e.g., lost circulation material) and the presence of such solids should be noted.

FIG. 5.1
SAND-CONTENT SET

State of California Business, Transportation and Housing Agency

Memorandum

: MR. FRANK YANAMURA, Chief
Office of Structure Construction

Attention: MR. MOHAMED FOUAD
Resident Engineer

Date : September 8, 1994

File No. : 11-SD-805-17.5/17.8
11-058503
Mission Valley Viaduct
Indicator Pile Test Program

From : **DEPARTMENT OF TRANSPORTATION**
ENGINEERING SERVICE CENTER
Office of Structural Foundations

Subject : Gamma Test Results

Gamma test results are attached for Shafts 2, 3, and 4 at Site 3 of the Mission Valley Viaduct Indicator Pile Test Program. Testing conducted by State personnel used a CPN Model 502 DR Depth Probe equipped with a 10 millicurie source of Cs137. Results presented herein were initially discussed during the Foundation Review meeting held on Wednesday, August 31, 1994 in Sacramento. A summary of relevant information is as follows:

Cast-in-place concrete Pile No. 2 consisted of an 24 m (80 ft) long by 1200 mm (48 in) diameter drilled shaft. Installation, which occurred between August 23 and August 29, utilized full length casing and polymer slurry drill fluid to hold the excavation open. Gamma testing occurred on August 29, 1994. No problems were reported related to tube blockage or water infiltration. In general pile integrity looked good. The only significant anomaly noted was at the top 1 m (3 ft) to 2 m (6 ft) of the shaft. On production piles, such an anomaly would warrant further evaluation. Due to the proximity of the anomaly to the ground surface, excavating surface material to allow direct evaluation would be the preferable course of action.

Cast-in-place concrete Pile No. 3 consisted of an 24 m (80 ft) long by 1200 mm (48 in) diameter drilled shaft. Installation, which occurred on August 25 and 26, utilized bentonite slurry to hold the excavation open. Gamma testing occurred on August 29, 1994. The only problem noted during testing occurred when the gamma probe would not pass beyond a depth of 21 m (70 ft) in tube No. 4. The other three tubes were read without difficulty. In general, the only significant anomaly noted was at the top 0.1 m (1 ft) to 0.6 m (2 ft) of the shaft. On production piles, such anomalies would warrant further evaluation. As with Pile No. 2, excavating surface material to allow direct evaluation would be the preferable course of action.

Cast-in-place concrete Pile No. 4 consisted of an 24 m (80 ft) long by 1200 mm (48 in) diameter drilled shaft. Installation, which occurred on August 22 through 24, utilized a polymer slurry to hold the excavation open. Gamma testing occurred on August 25, 1994. Tube No. 4 was read for the entire length of the shaft, while tubes 1 through 3 were blocked at depths of 20.2 m (66.4 ft), 4.5 m (14.8 ft), and 11.5 m (37.8 ft) respectively. Although these problems with probe access could be related to shaft defects, a more likely conclusion is that they occurred due to improper handling of the reinforcement cage during shaft construction. Accounts from field personnel support this assumption. Of the access tubes tested, the only significant anomaly noted was in Tube No. 4 at the bottom of the shaft. In an effort to further investigate the anomaly encountered

MR. MOHAMED FOUAD
September 8, 1994
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and to compensate for blocked access tubes, four additional 50 mm (2 in) diameter access holes were drilled. However, after water was encountered within each hole, efforts to conduct additional gamma testing was suspended by the State. At the consent of the Resident Engineer, the Contractor hired a consultant to test the original blocked shafts with a 25 mm (1 in) diameter waterproof probe having a 100 millicurie source of Cs137. Test results developed with this probe, faxed to this office on September 2, 1994, confirm the existence of an anomaly at the bottom of this shaft. If this was production work, we would recommend that this shaft be rejected.

If you have any questions or comments, please call me at (916) 227-7163 or (CalNet) 498-7163.

Keith E. Swanson

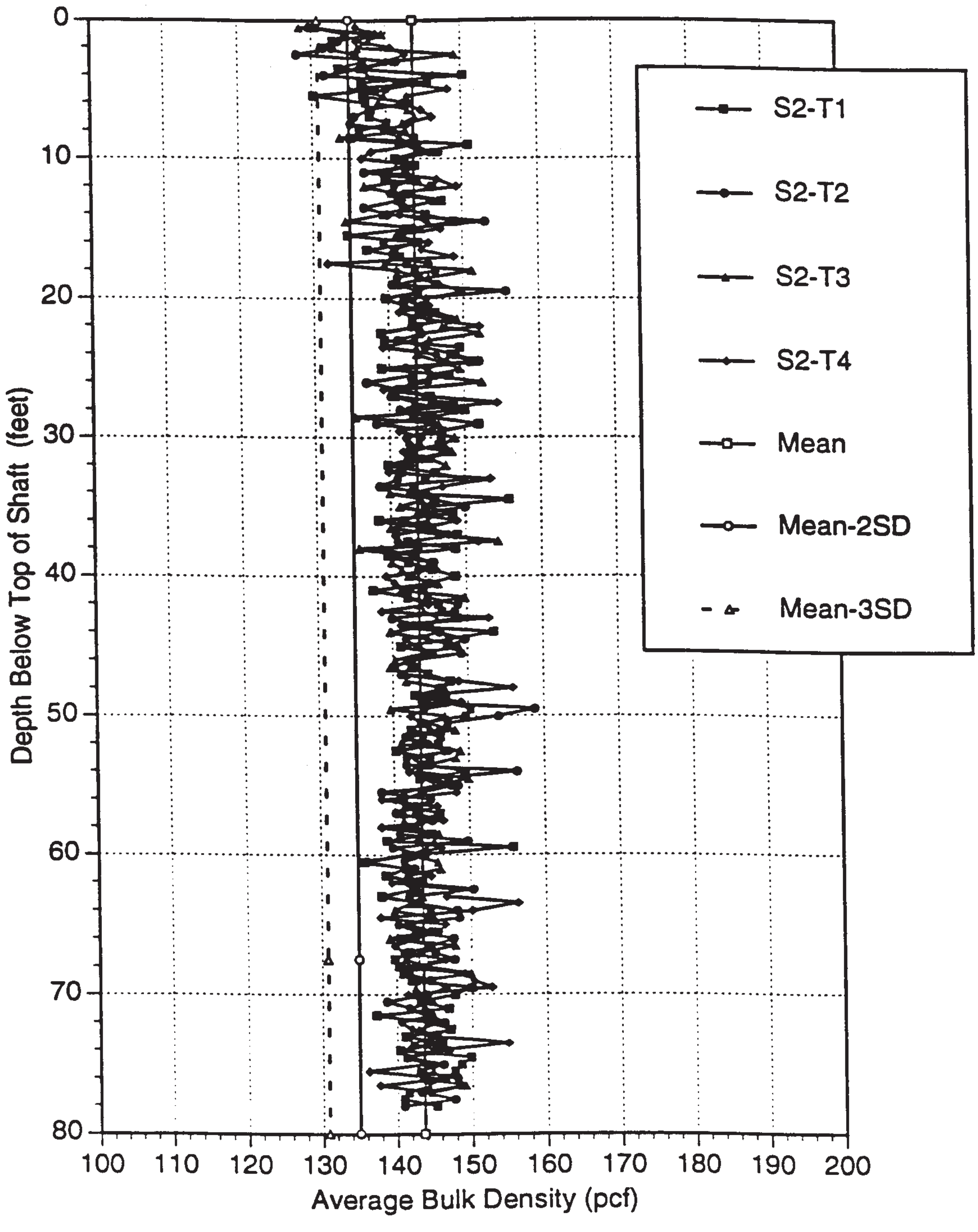
KEITH E. SWANSON
Associate Materials & Research Engineer
Foundation Testing and Instrumentation Section

Attachments

KES/jlm

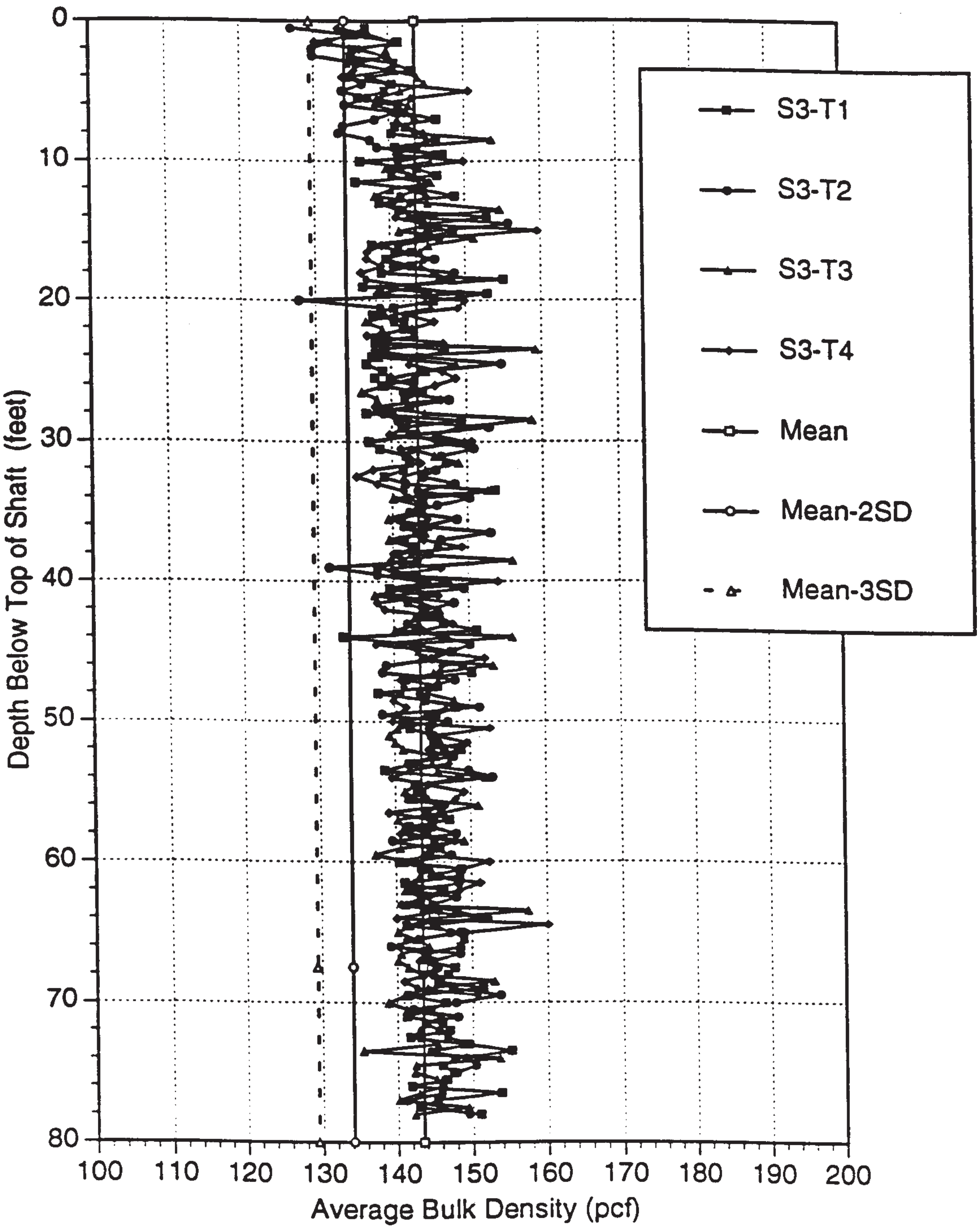
cc: ELeivas
DSpeer
AAbghari
TJensen-OSD
RStott-OSC
AAsnaashari-OSD
Pile Test File-OGE

REGISTERED PROFESSIONAL ENGINEER
KEITH E. SWANSON
No. GE 2267
Exp. 3/31/95
GEOTECHNICAL
STATE OF CALIFORNIA



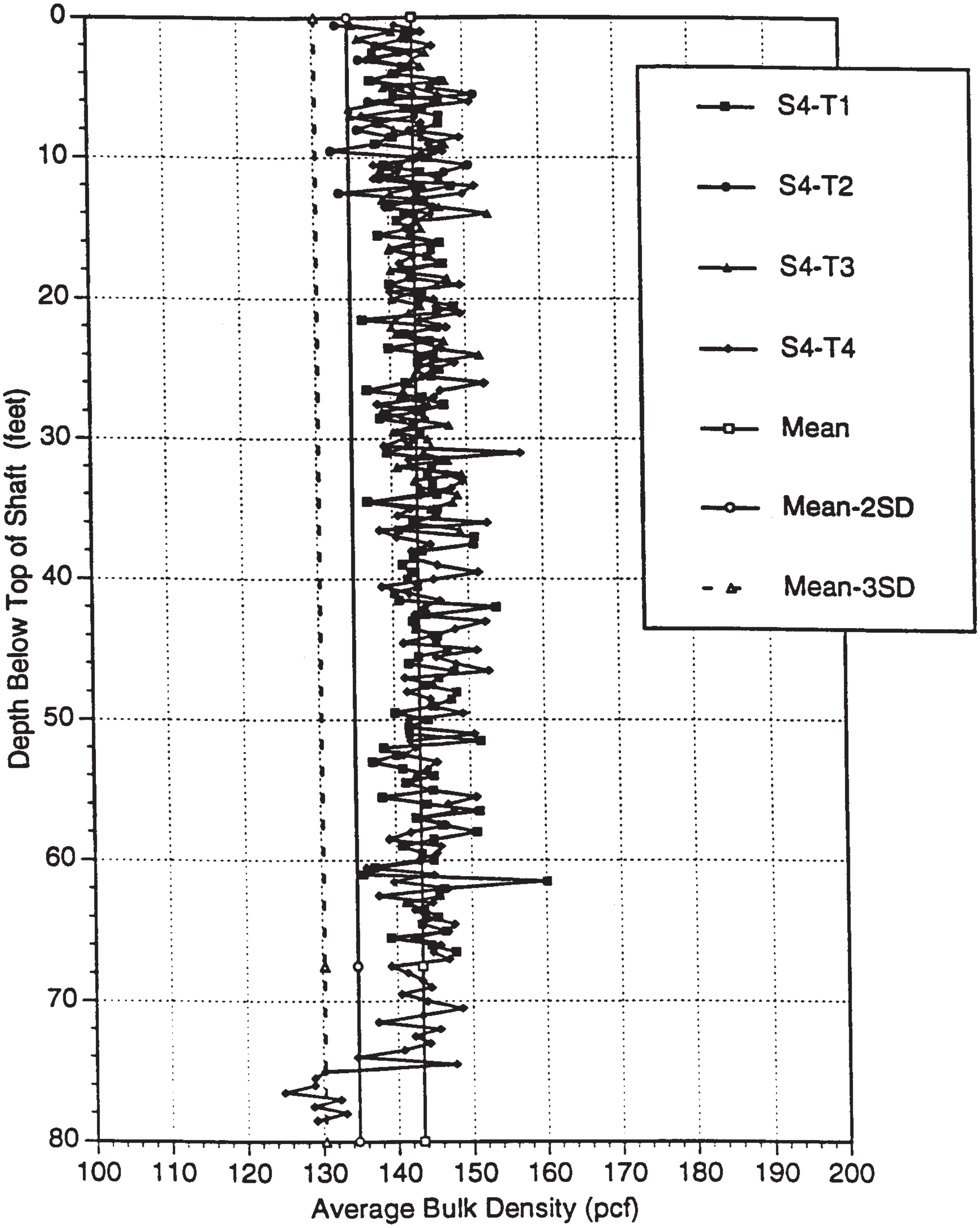
Gamma Test Data
Mission Valley Viaduct IPTP

11-SD-805	Site 3	Bridge No.57-0718F
11-058503	Shaft 2	Tested 8/94



Gamma Test Data
Mission Valley Viaduct IPTP

11-SD-805	Site 3	Bridge No.57-0718F
11-058503	Shaft 3	Tested 8/94



Gamma Test Data
Mission Valley Viaduct IPTP

11-SD-805	Site 3	Bridge No.57-0718F
11-058503	Shaft 4	Tested 8/94